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ASSOCIATION AND PHRASE STRUCTURE IN SENTENCE RECALL[1]

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The effect of within- and between-phrase normative controlled association and phrase structure upon word integration in sentence recall was studied in 2 experiments. The 2 experiments differed only with respect to the type of 2-phrase sentence used. In both experiments, one group of Ss was given 4 study-test trials on a list of 4 sentences containing associatively related words, while another group received a list containing associatively unrelated words. On the assumption that an integrated unit is one in which adjacent words are recalled together, the probability of a word-to-word transitional error (TE) was used as a measure of the tendency to integrate the words within the sentences into larger units. In both experiments, the results suggested that the words in low association (LA) sentences are recoded into phrase units, but that the words in high association (HA) sentences are recoded into units that transcend the phrase boundary. The results indicated further that the probability of a TE at the phrase boundary decreases as associative strength across the phrase boundary increases. In addition, the probability of a TE within phrases was higher for LA sentences in Experiment II than for HA sentences. However, in Experiment I, association did not influence TE probability within phrases.

Johnson (1965) has presented evidence to support the hypothesis that in learning a sentence, Ss tend to recode individual words into linguistic phrase units. He had reasoned that if the phrase is a psychologically real unit, the probability of a word-to-word transitional error (TE) in recall, i.e., the probability of failing to recall a word correctly, given that the previous word in a sentence is recalled correctly, should be greater for a between-phrase transition than for a within-phrase transition. On the basis of a theory of the operations involved in sentence generation, Johnson (1966) argued further that Ss would utilize an association within a phrase but not an association between phrases. By the theory, the operations involved in producing a phrase are adjacent, but not the operations involved in going from one phrase to the next. Johnson tested this hypothesis by establishing adjective-noun (within-phrase) and noun-verb (between-phrase) associations of similar strength and then having Ss learn sentences containing the word pairs, with results that supported the hypothesis.

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The interpretation of these results can be questioned, however, on the grounds that if there is a tendency to recode the words of a sentence into phrase units, the noun-verb association would have to be stronger than the adjective-noun association in order to reduce significantly the probability of a TE at the phrase boundary. Johnson's experimentally-established associations may have been adequate to facilitate the adjective-noun transition but not the noun-verb transition. A method for testing the hypothesis would be to use sentences that contain strong normative associations, rather than attempt to establish strong associations under the limiting conditions of the laboratory.

The effect of normative controlled associations upon between- and within-phrase TE probabilities in sentence recall was evaluated in the two studies (which differed only with respect to sentence type) reported here. In both studies, Ss were exposed to sentences that contained strong between- and within-phrase associations or to sentences that contained weak associations throughout. It was anticipated that the presence of strong normative associations would make it possible to recode the words within a sentence into units larger than the phrase, the result of which would be a reduction in between- and within-phrase TE probabilities.

Experiment I

Method

Subjects. Forty-eight paid undergraduate volunteers were assigned without bias to two groups of 24 Ss each. The Ss in each condition were tested in groups of three to eight. Data for an intralist associative interference condition not relevant to the present problem were collected from other Ss as part of this study.

Materials. Two lists--a high association (HA) and a low association (LA) one--were prepared, one for each of the two groups. Each list consisted of four sentences in the form: article - adjective - noun - verb - adverb. The HA and LA sentences were constructed from controlled association norms obtained from 288 undergraduate Ss. The Ss in the norm study were given a series of nouns, each of which was embedded in the sentence frame, and were required to associate an adjective, a verb and an adverb within each frame. The HA sentences used in the present study (e.g., The old king ruled wisely) contained

high-strength adjective-noun (AN), noun-verb (NV) and verb-adverb (VAv) associative dependencies. In terms of the entire sentence, the adjective-verb-adverb combination in each HA sentence was one that occurred with high frequency in the presence of the subject noun. The LA sentences (e.g., The poor king dined gravely) contained the same nouns as the HA sentences, but the adjective, verb and adverb in each occurred with a frequency of one or two in the norms.

The adjectives, nouns, and verbs in Lists HA and LA were all A or AA words in the Thorndike and Lorge (1944) norms. The average T-L frequency of the adverbs in the HA list was 24; in the LA list it was 21. The HA and LA words were matched as closely as possible on length, and the sentences for each list were selected so as to avoid intralist associative interference.

The sentences were printed in booklets, one sentence to a page. Each booklet contained four repetitions of a list. The page that followed the last item in a list was blank and lined, and was used for written recall. Four orders of each list were constructed, each of which occurred equally often on each of the four trials within each experimental condition. Exposure intervals were timed with a metronome and the retention tests with a stop-watch.

Procedure. Each sentence was exposed for 5 sec., each study trial was followed immediately by a 1-min. written recall test, and there was a 5-sec. intertrial interval. The Ss were given detailed instructions in the use of the booklets, and were told that their task was to try to learn as many of the sentences as they could without regard for the order of the sentences within the list. The recall task was to write down as much of each sentence as they could remember, and to try to guess at items they could not remember. The signal to turn each page was delivered orally by E.

Results

The written recall protocols were scored for verbatim recall, and the scores were summed over trials. Mean sentence recall was 12.92 in Group HA and 9.92 in Group LA. This difference in favor of Group HA is significant; t (23) = 4.41, $p < .001$, one-tailed. Group HA was also superior to Group LA in the proportion of words recalled correctly in the form of complete sentences. The means on this measure were .87 and .77. This difference is also significant:

t (23) = 2.50, $p < .01$, one-tailed. The df were halved in these analyses because of heterogeneity of variance (Edwards, 1960). Table 1 contains the means for content-word recall in relation to position within the presented sentences. It can be seen from Table 1 that Group HA was superior to Group LA at all sentence positions. It appears also that the serial position curve differed for the two groups. An analysis of variance of these data revealed F (1,46) = 39.55, $p < .001$ for Association, F (3,138) = 27.32, $p < .001$ for Position, and F (3,138) = 5.51, $p < .005$ for the interaction between Association and Position. The significant interaction appears to be the result of the difference between the groups in the serial position function. There was a low level of recall of adjectives, verbs and adverbs in relation to nouns in Group LA. In Group HA, however, both nouns and verbs were recalled better than adjectives and adverbs.

Insert Table 1 About Here

The mean TE probabilities (based upon the recall data summed over sentences and trials) for each S for the various word-to-word transitions for the two experimental groups can be found in Table 2. To compute a TE probability, the frequency with which a word following a correct word was wrong (an overt error or no word at all) was divided by the frequency with which the preceding word was correct. If there was a tendency to recode the strings into units larger than the word but smaller than the sentence, the TE probabilities should be unequal. The Friedman two-way analysis of variance was used to evaluate the hypothesis in both groups. The value of χ^2_r (3) for Group HA was 13.71, $p < .01$; for Group LA it was 24.69, $p < .001$. Thus, Transition No. had a significant effect upon TE probability, but it is to be noted that the pattern of TE probabilities differed for the two experimental groups. The LA condition shows a high point at the phrase boundary (Transition No. 3), but not the HA condition.

Insert Table 2 About Here

According to Johnson (e.g., Johnson, 1965), if there is a tendency to recode the words within each sentence into phrase units, the probability of a TE at the phrase boundary should be greater than the probability of a TE

for the other transitions. This hypothesis is tested by comparing the probability of a TE at the phrase boundary with the mean of the other transitions using the Wilcoxon matched-pairs signed-ranks test. For Group HA the means in question were, respectively, .03 and .06, and for Group LA they were .18 and .10. These differences are significant ($p < .005$, one-tailed), but the direction of the effect for Group HA is clearly the opposite of what was predicted by the phrase structure hypothesis. Thus, while there is evidence that phrase structure contributes to the recall of LA sentences, the words in the HA sentences appear to have been recoded into a unit that includes the NV transition.

Table 2 reveals that for each transition, the probability of a TE is lower for Group HA than for Group LA. Of special interest are the AN, NV and VAv transitions. The Mann-Whitney U test was employed to evaluate these differences. The difference for the NV transition was highly significant ($z = 4.43$, $p < .001$, one-tailed), but the other differences were nonsignificant. Contrary to the results of Johnson's (1966) study, the probability of a TE at the phrase boundary is influenced by association, but not the probability of a TE within phrases.

The TE probabilities for Trial 1 were examined to determine whether there was any tendency initially for the words in HA sentences to be recoded into phrase units. However, the statistical results for Trial 1 were found to be identical with the overall results.

Experiment II

Experiment II was designed to test the generality of the results of Experiment I by using sentences identical in syntactic structure and length to the two-phrase sentences used by Johnson in his work.

Method

Subjects. The Ss were 40 paid undergraduate volunteers who were assigned without bias to an HA ($N = 20$) and an LA ($N = 20$) group and tested in groups of from three to eight.

Materials. There were four HA sentences (e.g., The brave soldier fought the cruel war) and four LA sentences (e.g., The rich soldier liked the green house). The HA and LA sentences contained the same subject nouns, and they were equated on Thorndike and Lorge (1944) word frequency (primarily AA and A

words) and on length (average number of letters). The basic sentences (e.g., The soldier fought the war) were constructed from controlled association norms (N = 120) for subject nouns embedded in a simple declarative sentence frame in a manner similar to the procedure used to generate the sentences of Experiment I. The basic sentences (with a blank space before each of the nouns) were then given to another group of Ss (N = 44) in order to obtain controlled adjective responses. Thus, with respect to the example given above, brave and cruel were response primaries, while rich and green were selected from the bottom of the associative frequency hierarchies. The HA and LA sentences were constructed so as to avoid intralist associative relationships.

The booklets used to present the sentences were identical in all respects to the booklets used in Experiment I.

Procedure. The procedure used in Experiment I was duplicated in Experiment II.

Results

The mean number of sentences recalled correctly over the four trials in Group HA was 12.95, and in Group LA it was 7.45. The difference in favor of Group HA is highly significant; t (19) = 6.71, $p < .001$, one-tailed. Group HA recalled proportionally more words in sentences than Group LA. The means were, respectively, .88 and .60. This difference is also highly significant; t (19) = 5.60, $p < .001$, one-tailed. It was necessary in these analyses to reduce the df by half because of heterogeneity of variance. Table 3 contains the means for content-word recall in relation to position within the presented sentences. Here also, Group HA was superior to Group LA at all sentence positions. In addition, the serial position function for Group HA appears to be flatter than the serial position function for Group LA. Analysis of variance of these data revealed significant main effects for Association, F (1,38) = 40.83, $p < .001$, and Position, F (4,152) = 10.66, $p < .001$, and a significant interaction between Association and Position, F (4,152) = 6.76, $p < .001$.

Insert Table 3 About Here

The mean TE probabilities computed over trials and sentences for the six word-to-word transitions within the sentences can be found in Table 4. In general, the TE probabilities for the HA condition were lower than the

TE probabilities for the LA condition. The Friedman two-way analysis of variance produced a $X_r^2(5)$ for Group HA that does not even approach significance, but for Group LA it is highly significant; $X_r^2(5) = 35.29$, $p < .001$.

Insert Table 4 About Here

Since there was no overall effect of Transition No. in Group HA, no further comparisons were made within this group. To determine whether there was a tendency to recode words into phrases in Group LA, the Wilcoxon test was used to compare the TE probabilities for Transition No. 3 (NV) with the means of the other transitions. The group means for these values were, respectively, .22 and .10. The between-phrase transition is significantly higher ($p < .005$, one-tailed) than the mean of the other transitions, a finding which is consistent with the phrase structure hypothesis.

To determine the effect of normative associative strength for a given transition, Group HA was compared with Group LA on the first AN transition (No. 2), the NV transition (No. 3), and the second AN transition (No. 6), using the Mann-Whitney U test. The results indicate $p < .05$ (one-tailed) for Transition No. 2, $p < .001$ (one-tailed) for Transition No. 3 and $p < .01$ (one-tailed) for Transition No. 6. Thus, for the sentences of Experiment II, the probability of a TE decreases as a function of normative associative strength for both within- and between-phrase transitions.

The TE probabilities on Trial 1 were examined to determine whether there was any tendency initially to recode the words in HA sentences into phrase units. With one exception, the statistical results for Trial 1 are identical with the results for overall performance. The exception is that associative strength does not affect the TE probability for the first AN transition.

General Discussion

While there was some evidence in the present studies for phrase chunking in the case of LA sentences, there was no evidence to suggest that in learning HA sentences, Ss recode adjacent words into linguistic phrase units. The results suggest, rather, that associatively integrated sentences (as herein defined) are processed in units that transcend the phrase boundary. In the

case of the sentences of Experiment II, the evidence suggests that the functional unit is the whole sentence. In both experiments, the within-group TE probabilities were clearly related to differences in the recall of HA and LA words. For one thing, proportionally more HA words were recalled in complete sentences than LA words, and for another, verbs were recalled almost as well as nouns in the HA sentences, whereas in the LA sentences there was an appreciable drop in recall as Ss went from the noun to the verb.

In contrast with Johnson's (1966) findings, the probability of a TE at the phrase boundary is influenced by associative constraint. The reason for Johnson's failure to find a significant effect of association at the phrase boundary was perhaps that he had used experimentally established associations. As indicated earlier, the effectiveness of his experimentally established associations for a within-phrase transition could be accounted for by assuming that if there is a strong tendency toward phrase chunking, it may take the strength of a normative association to overcome it, whereas an experimentally established association may be adequate to facilitate a within-phrase transition. Unfortunately, this account does not explain the results of Experiment I, where normative associative facilitation was found to occur between phrases but not within phrases. There is obviously a need for research on the effect of such variables as sentence type and length upon syntactic and associative-semantic integration within a sentence.

The general implication of the results of the present studies is that in the learning of a sentence, the words are recoded for storage into the largest chunks possible, in accordance with the syntactic and associative-semantic structure of the sentence. Such a strategy would reduce the number of memory units to be stored while increasing the amount of information per unit. A further implication is that the associative-semantic relations revealed by controlled association norms are of greater importance in sentence recall than phrase structure.

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Footnote

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Table 1

Mean Number of Content Words Recalled as a Function of Position Within the Sentence

Group	Position			
	Adjective	Noun	Verb	Adverb
HA	14.21	15.67	15.21	14.33
LA	12.25	14.38	12.00	11.92

Table 2

Mean TE Probabilities for Each Word-to-Word Transition

Group	Transition No.							
	Article	1	Adjective	2	Noun	3	Verb	4	Adverb
HA		.10		.01		.03		.07	
LA		.19		.02		.18		.10	

Table 3

Mean Number of Content Words Recalled as a Function of Position Within the Sentence

Group	Position				
	Adjective	Noun	Verb	Adjective	Noun
HA	14.45	15.15	14.70	14.05	14.50
LA	11.10	13.40	11.10	12.45	12.60

Table 4

Mean TE Probabilities for Each Word-to-Word Transition

Group	Transition No.											
	Art.	1	Adj.	2	N.	3	V.	4	Art.	5	Adj.	6	N.
HA		.07		.02		.02		.01		.05		.02	
LA		.23		.09		.22		.02		.07		.10	